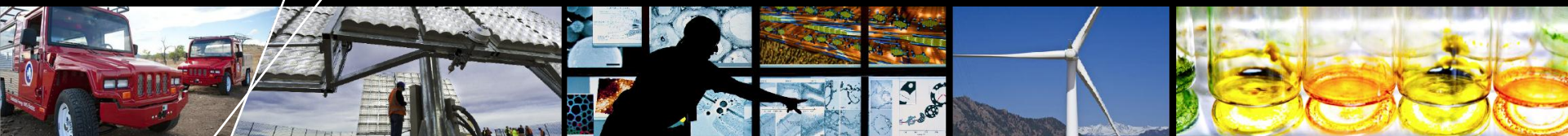# Are Integration Costs and Tariffs Based on Cost-Causation?

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## Transmission and Grid Integration Group, NREL

About This Presentation

- **Most information in this presentation is taken from the more comprehensive technical report *Cost-Causation and Integration Cost Analysis for Variable Generation* by Michael Milligan, Erik Ela, Bri-Mathis Hodge, Brendan Kirby, Debra Lew, Charlton Clark, Jennifer DeCesaro, and Kevin Lynn**

- **www.nrel.gov/docs/fy11osti/51860.pdf**
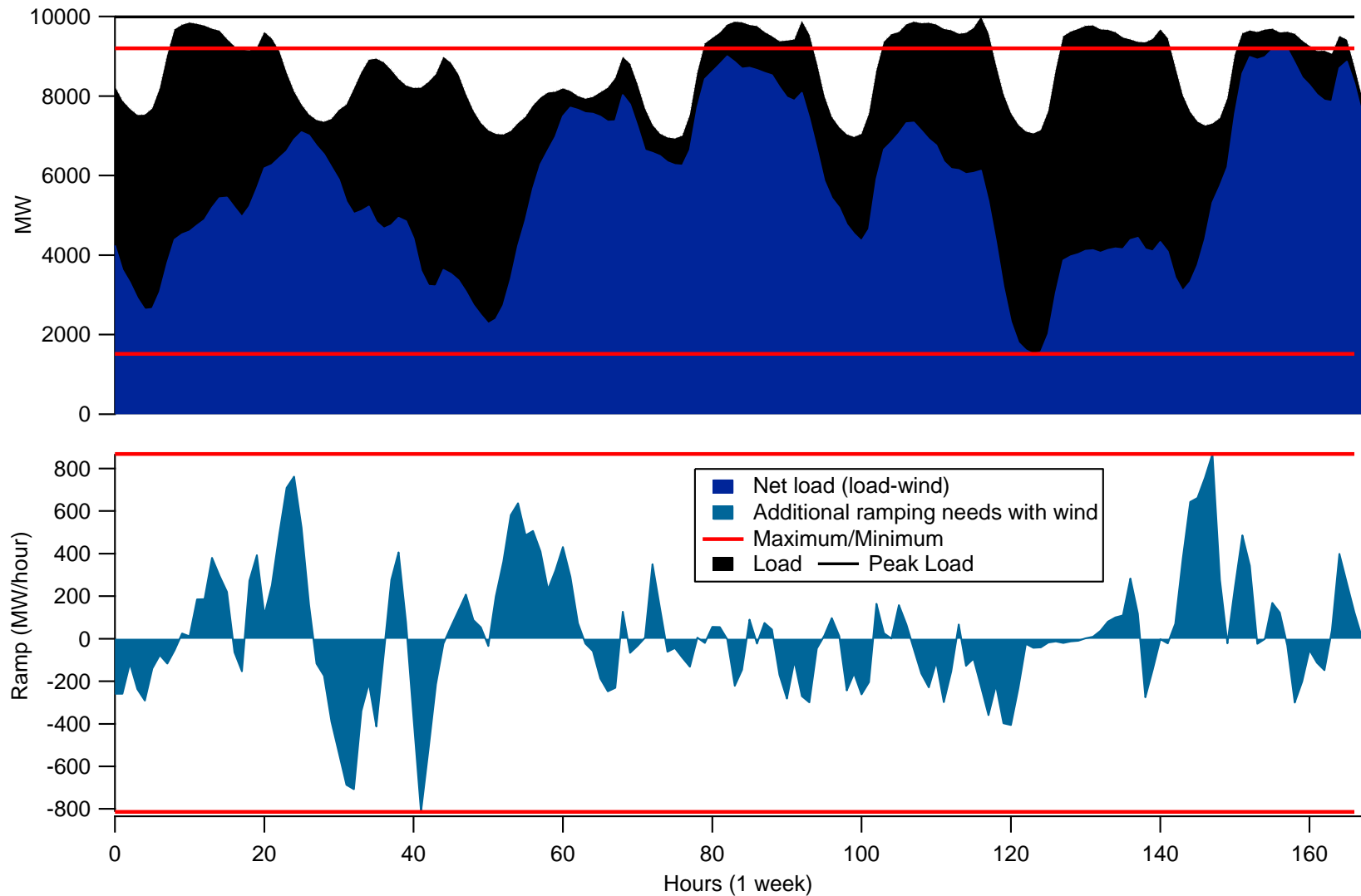
Outline/Headlines

- **Integration costs are difficult to calculate correctly**

- **Other types of generation can impose integration costs**

- **Technology- or performance-based integration cost?**

Time Scale for Power System Operations
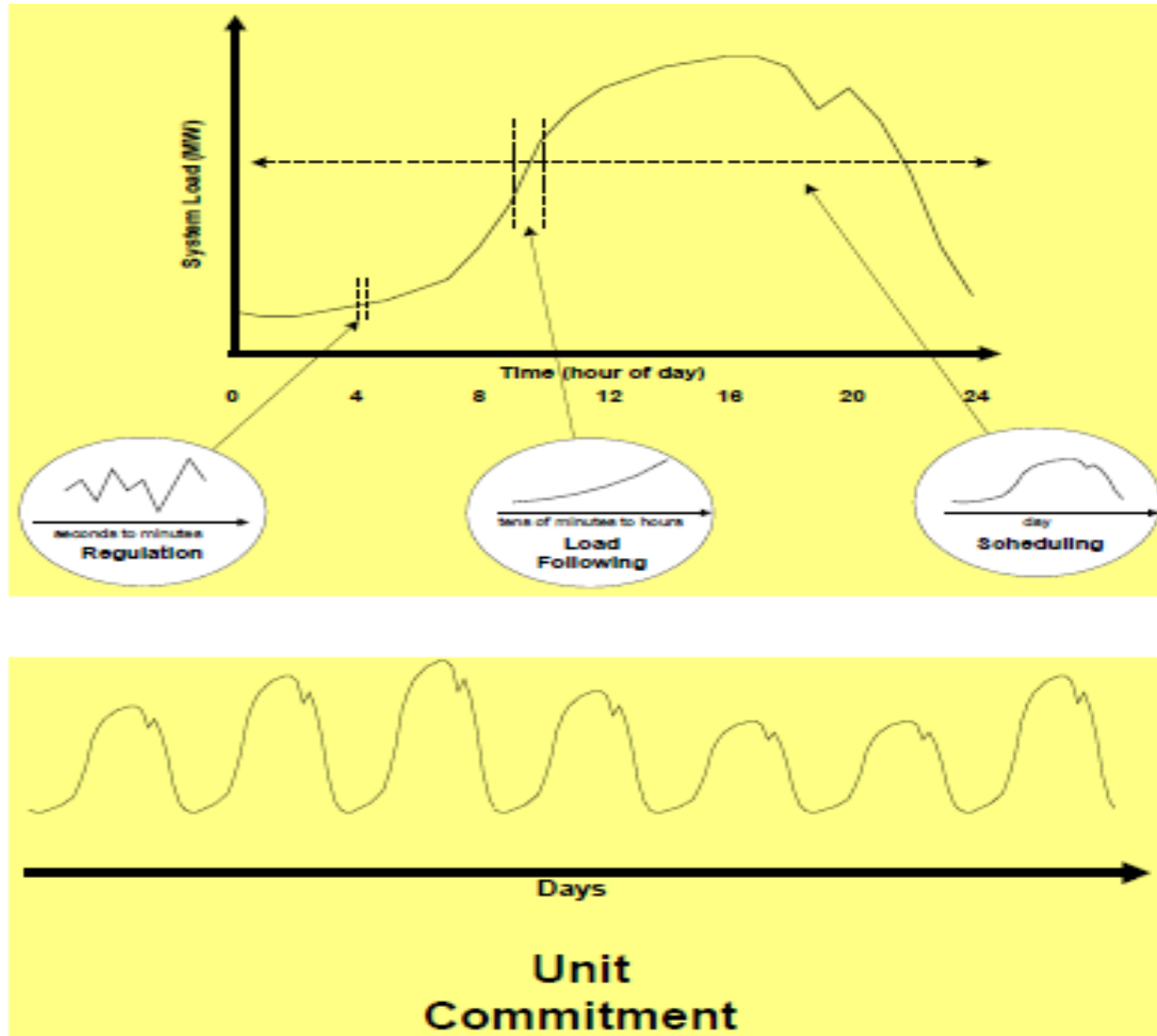
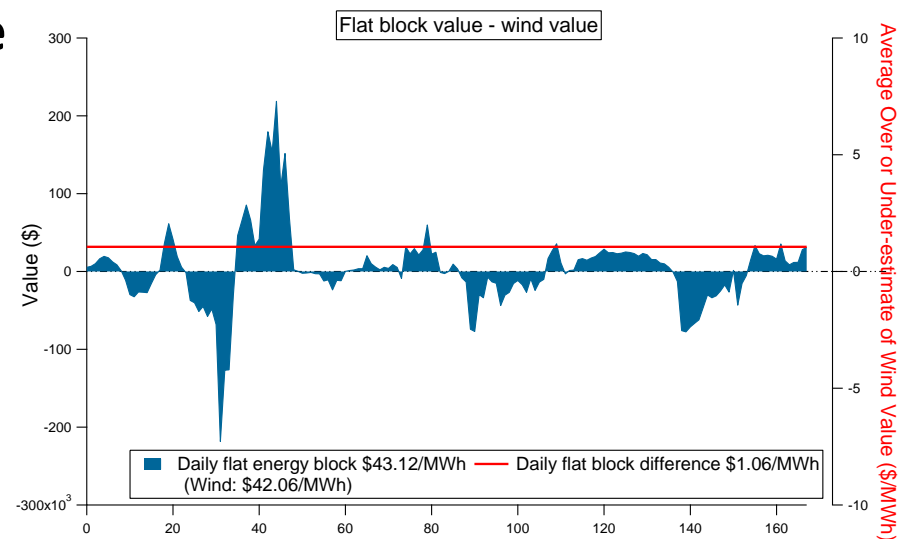# Additional Ramping/Range→More Flexibility

Integration Costs: Wind and Solar

- **Wind and solar generation increase the variability and uncertainty in power system operations**

- **Solar and wind integration issues are similar**

- **Cycling efficiency and flexibility reserves are key components**

- **These are not unique to wind or solar**
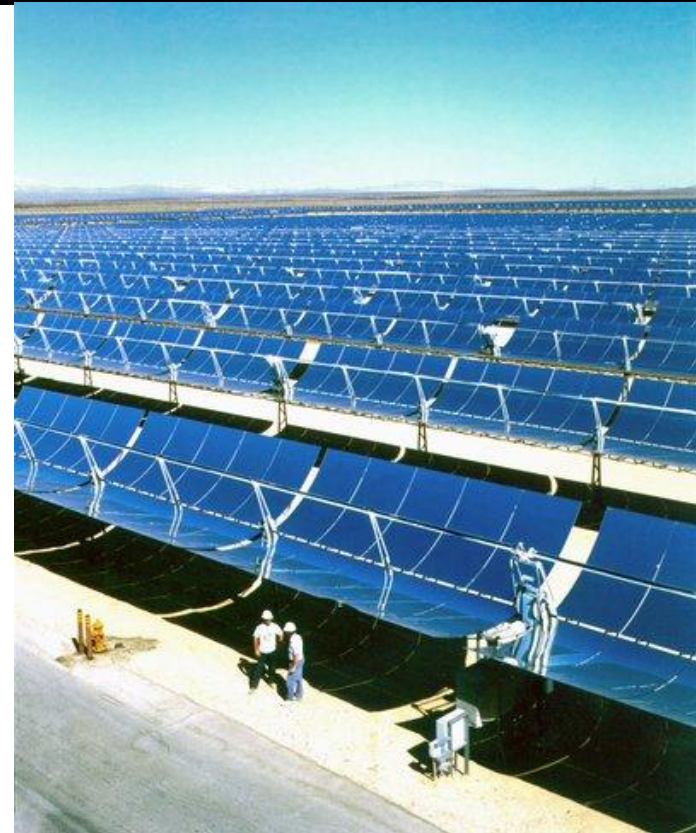
How Are Integration Costs Calculated?

- **Compare two (or more) alternative simulations of the power system using production simulation/cost models**
    - With wind/solar
    - Without wind/solar
- **To provide an energy-equivalent basis, a hypothetical unit is often chosen for the "without wind/solar" case**
- **This proxy resource may introduce unintended consequences**
- *It is natural to ask about integration costs, but extremely difficult, if not impossible, to measure them accurately*

Flat block value - wind value

Legend:
- Daily flat energy block $43.12/MWh (Wind: $42.06/MWh)
- Daily flat block difference $1.06/MWh

Y-axis (left): Value ($)
Y-axis (right): Average Over or Under-estimate of Wind Value ($/MWh)

Integration Costs of Wind and Solar

- **Can they be measured?**
- **If so, how are they defined?**
- **What are the proper benchmark units?**
- **How are cost and value untangled?**
- **What about units in one region that economically respond to needs in another region?**
- **Are there integration costs for other units?**
  - Do all automatic generation control units follow the signal?
  - Are there efficiency costs of adding conventional generators?
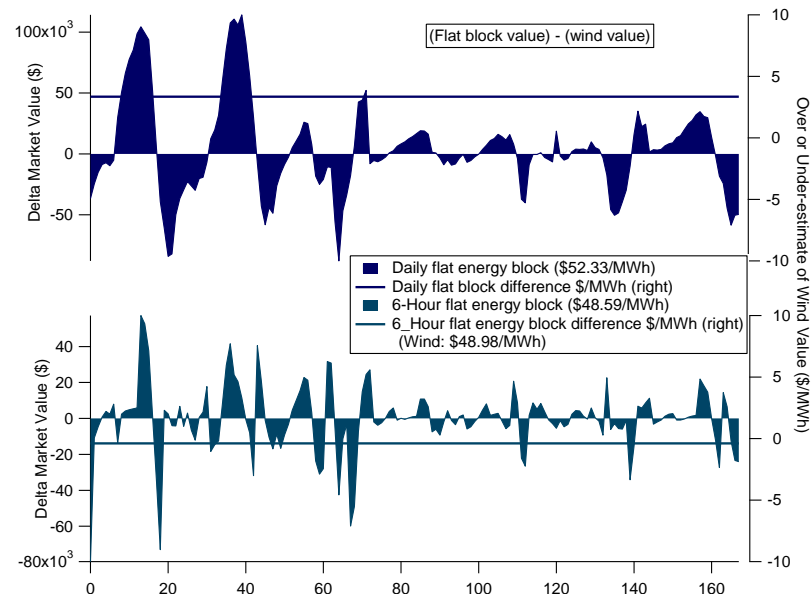
Related reports:

Milligan, M.; Kirby, B. (2009). *Calculating Wind Integration Costs: Separating Wind Energy Value from Integration Cost Impacts.* 28 pp.; NREL/TP-550-46275. www.nrel.gov/docs/fy09osti/46275.pdf

Milligan, M.; Ela, E.; Lew, D.; Corbus, D.; Wan, Y. H. (2010). "Advancing Wind Integration Study Methodologies: Implications of Higher Levels of Wind." 50 pp.; NREL/CP-550-48944. www.nrel.gov/docs/fy10osti/48944.pdf

Total System Costs or Integration Costs

- **Total operating costs are relatively easy to calculate**

- **Integration costs are difficult to calculate correctly**

- **Both of these are sensitive to assumptions about the other parts of the power system**
  - What is the mix of conventional generation?
  - What is the transmission build-out (if any)?
  - What are the institutional constraints?
  - What is the electrical footprint?
  - Do markets allow access to physical capability that exists, or is this access constrained?
  - What will the power system look like in 20xx?

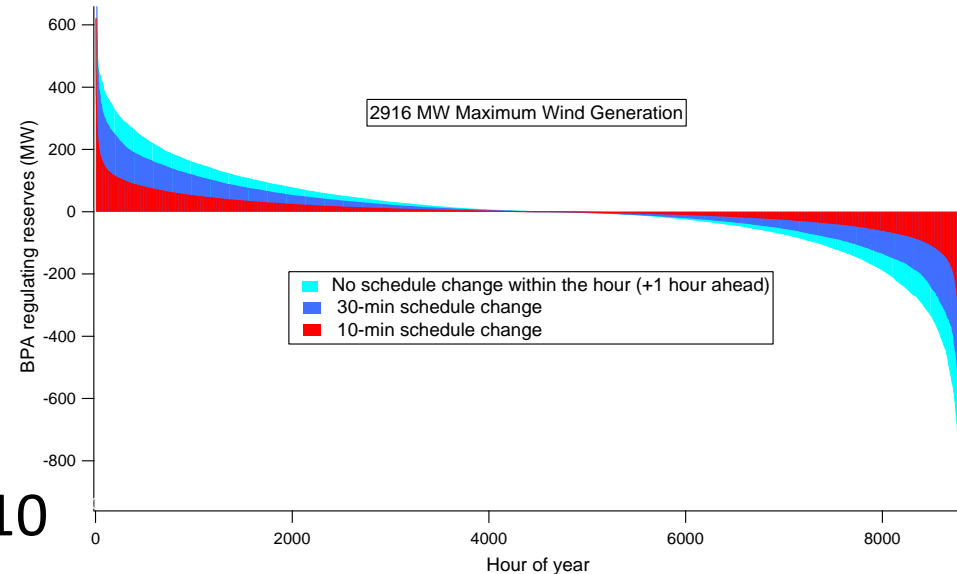# Integration Costs and Cost-Causation

- **Principles of cost-causation (see report)**

- **Cost-causer: must cause the cost**

  - ○ → If cost-causer is removed, so is the cost

  - ○ If costs change, then agent of change is responsible

  - ○ May be difficult to untangle

Are there other sources of integration costs?

Sources of Integration Costs: Scheduling/Dispatch

- **Hourly block schedules**
  - Impact of hourly schedules on BPA wind exports
  - California Intermittency Analysis Project/GE 2007
  - NREL's Western Wind and Solar Integration Study, 2010
- **Contingency reserves**
- **New low-cost base-load**
- **Conventional generators (thermal) that don't follow automatic generation control signal**

2916 MW Maximum Wind Generation

No schedule change within the hour (+1 hour ahead)
30-min schedule change
10-min schedule change

Milligan, M.; Kirby, B.; King, J.; Beuning, S. (2011). "The Impact of Alternative Dispatch Intervals on Operating Reserve Requirements for Variable Generation. Presented at 10th International Workshop on Large-Scale Integration of Wind (and Solar) Power into Power Systems." Aarhus, Denmark. October.

Contingency Reserves

- **Specific rules vary, but the contingency reserve is typically set by the largest unit in the pool**

- **Often the specific reserve allocation is based on load ratio share or another similar metric**

- **When the largest unit is replaced by a still-larger unit, contingency reserve obligations increase**

- *→ if I am a generation owner/operator, I will find my contingency reserve obligation may increase independently of any action I have taken (or not taken)*

Contingency reserve costs could be allocated based on generators' contribution to contingency reserve activation…but this is not done.
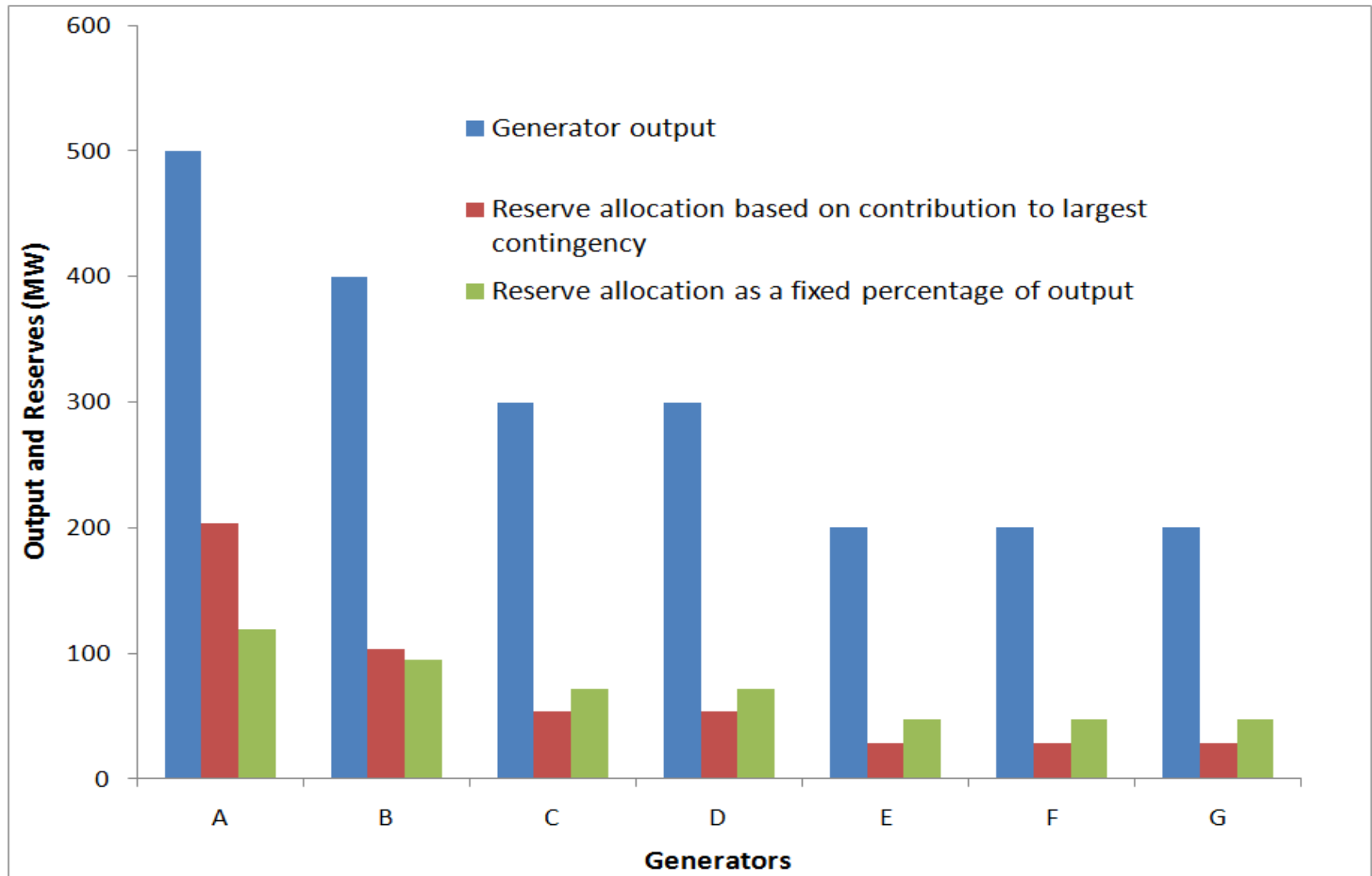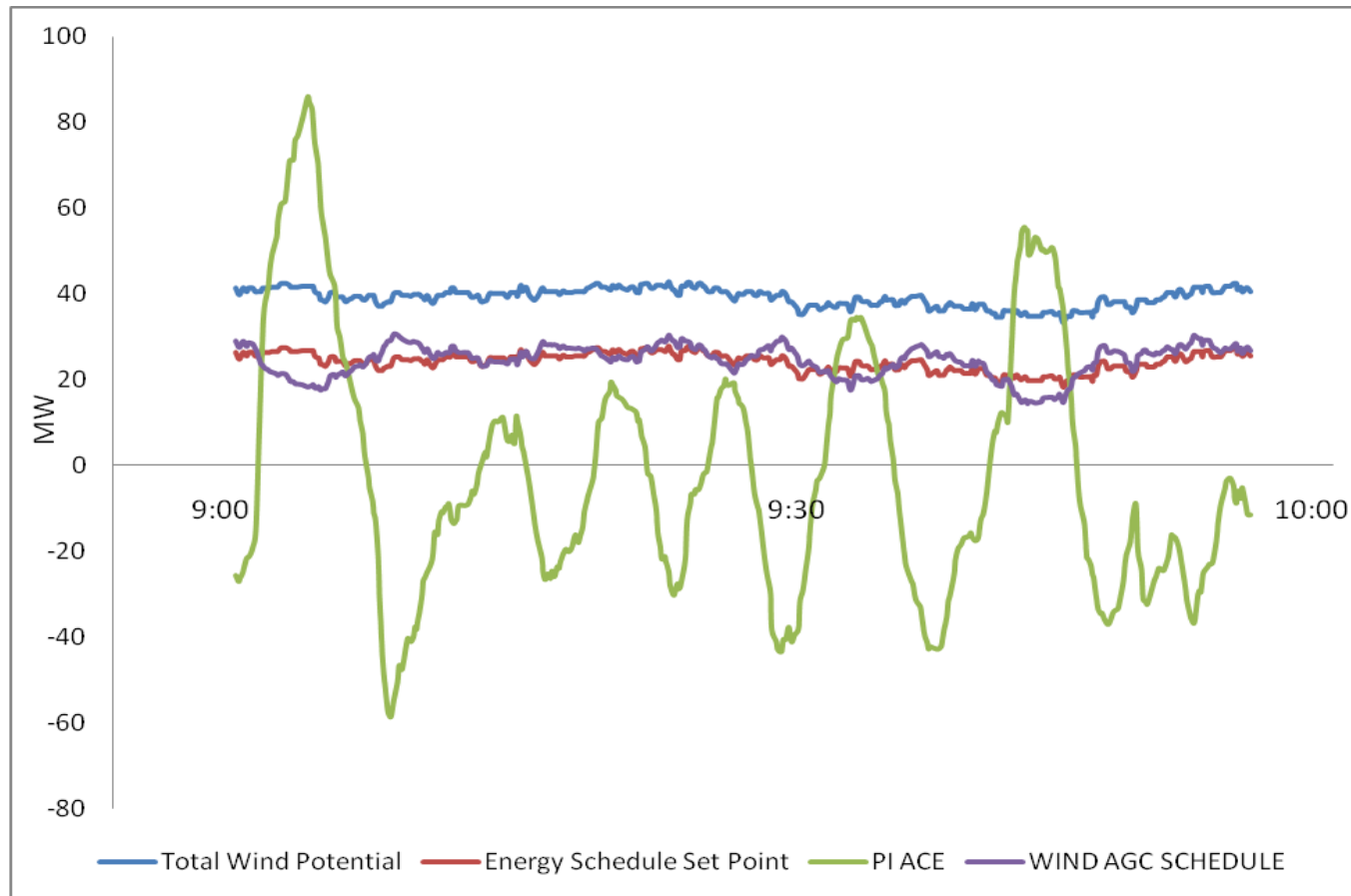
Conventional Units May Impose Regulation Costs

Two similar coal-fired generators: both are selling regulation, but the upper generator is following dispatch instructions fairly well providing regulation while the lower generator is not and is imposing a regulation burden on the power system.
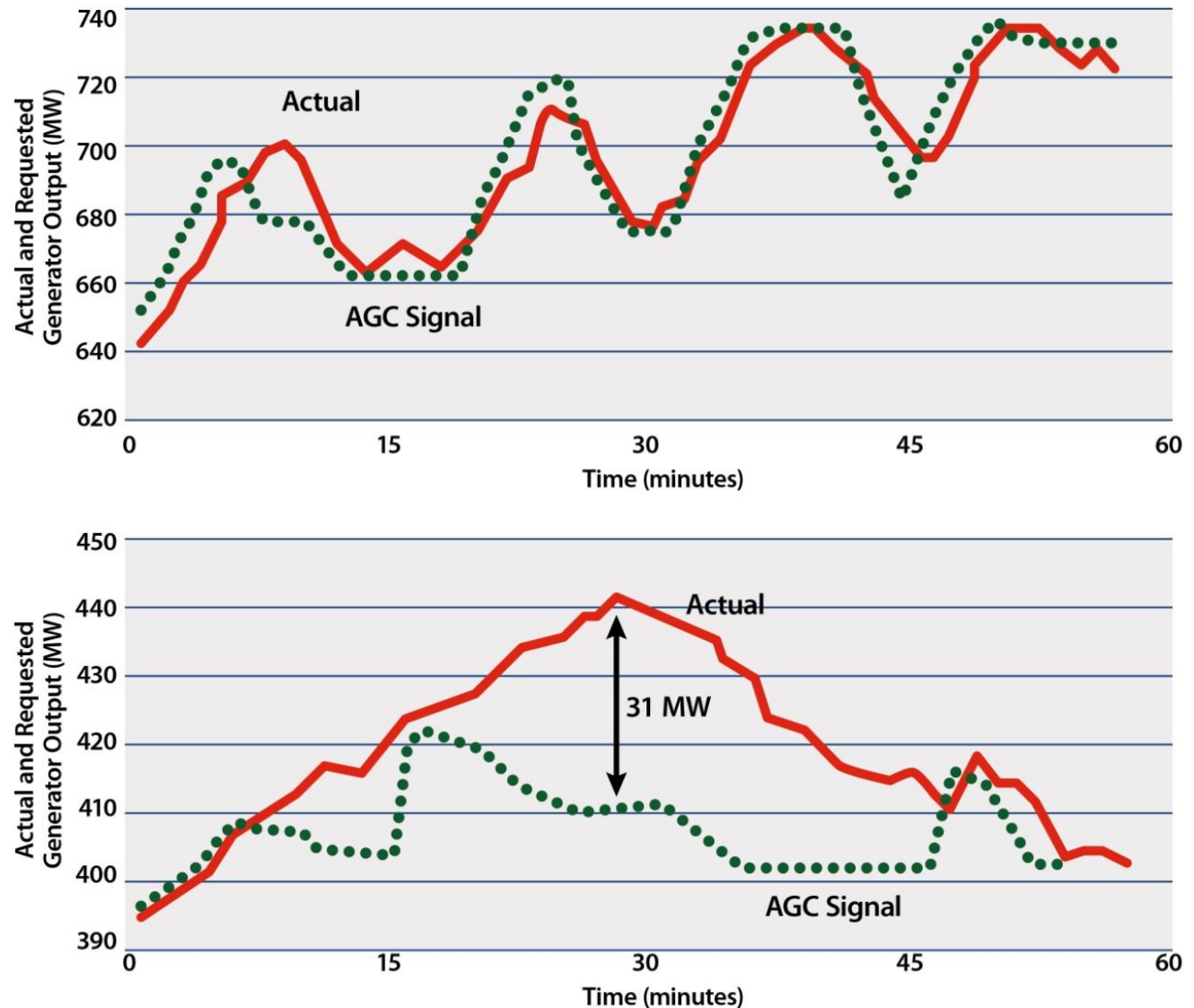
Wind Plants May *Provide* Regulation!

Wind plant providing 15 MW regulation to a system with 150-MW requirement.

Kirby, B.; Milligan, M.; Ela, E. (2011). "Providing Minute-to-Minute Regulation from Wind Plants." *9th International Workshop on Large-Scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Power Plants Proceedings*; October 19-19, Quebec, Canada.

New, Low-Cost Base-Load May Cause Integration Costs

1. Coal is operated as a base-load unit

2. With new wind generation added, gas and coal cycling increase and capacity factors decline

3. Instead of adding wind, a new, cheap base-load technology is introduced. Coal cycling increases; gas is nearly pushed out. Both coal and gas have lower capacity factors.
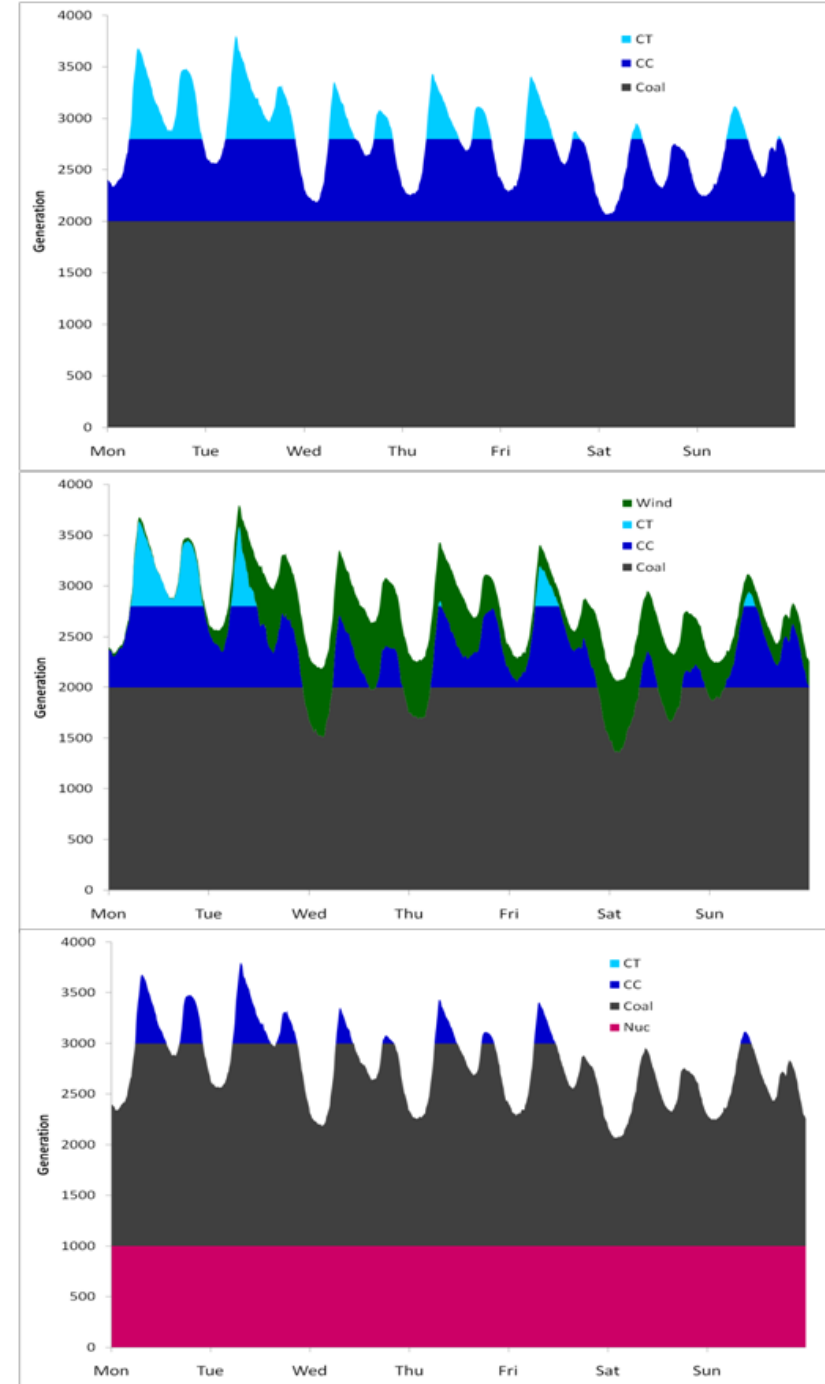
Performance Metric vs. Generation Type
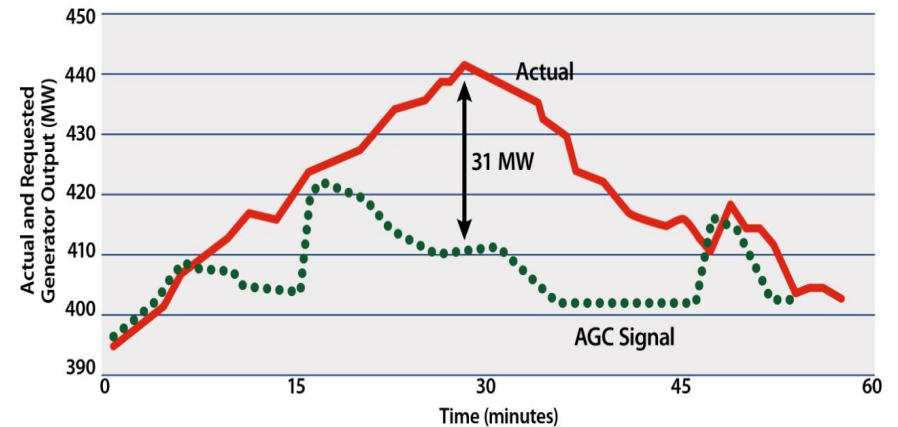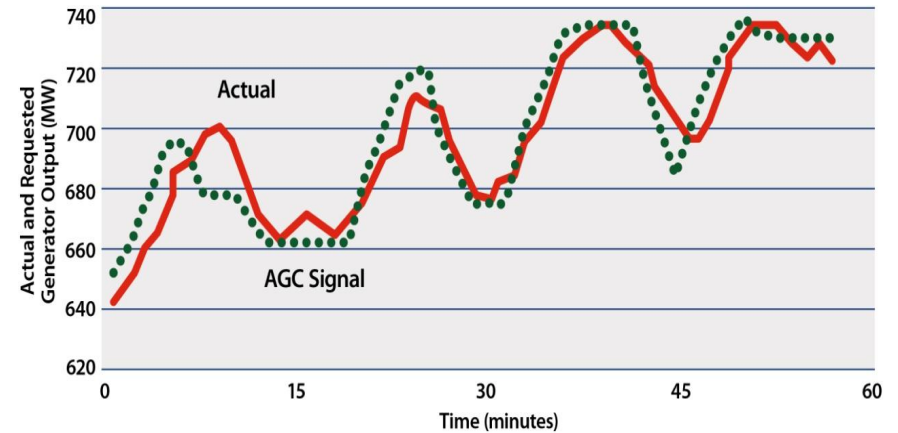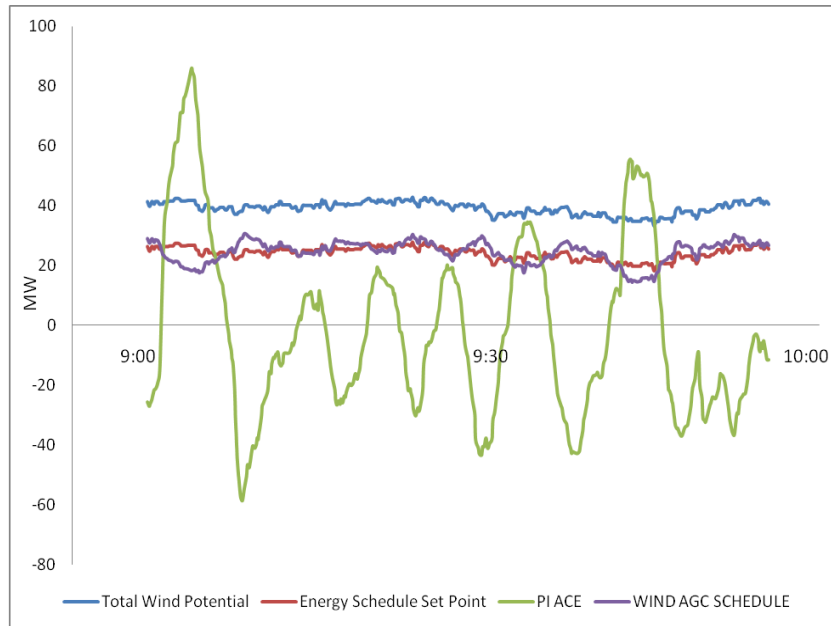
Summary

- **Wind (and solar) integration costs are very difficult to calculate correctly**

- **Other technologies can impose integration costs**

- **→ If integration costs are to be assessed, a performance-based metric would be more appropriate...or perhaps none at all**